Schottky diode. Although the method is depicted as a sequence of numbered steps for clarity, the numbering does not necessarily dictate the order of the steps. It should be understood that some of these steps may be skipped, performed in parallel, or performed without the requirement of maintaining a strict order of sequence. The method starts at Step **900**.

[**0052**] Step **902** provides a substrate. Step **904** forms a metal bottom electrode (MBE) overlying the substrate, having a first work function. Step **906** forms a semiconductor layer overlying the metal bottom electrode, having a second work function, less than the first work function. In one aspect an additional step, Step **907**, dopes the semiconductor layer with either an n-type or a p-type dopant. Step **908** forms a metal top electrode (MTE) overlying the semiconductor layer, having a third work function, greater than the second work function.

[**0053**] In one aspect, forming the metal top electrode (Step **908**) and metal bottom electrode (Step **904**) includes forming the metal electrodes from materials such as Pt, Au, Ag, TiN, Ta, Ru, or TaN, to name a few examples. In another aspect, Steps **904** and **908** form the metal bottom and top electrodes, respectively, from the same material. Therefore, the top and bottom electrodes have identical work functions.

[**0054**] In a different aspect, forming the semiconductor layer in Step **906** includes forming the semiconductor layer from a material such as a:Si, polycrystalline Si, InOx, or ZnO. Step **906** may deposit the semiconductor material using a process such as atomic layer deposition (ALD), chemical vapor deposition (CVD), physical vapor deposition (PVD), spin-coating, direct current (DC) sputtering, radio frequency (RF) sputtering, or metalorganic chemical vapor deposition (MOCVD).

[**0055**] In one aspect, forming the semiconductor layer in Step **906** includes depositing the semiconductor material to a thickness in the range of about 10 nm to 100 nm. Forming the metal top electrode in Step **908** and the metal bottom electrode in Step **904** includes forming each electrode with a thickness in the range of about 30 to 200 nm.

[**0056**] FIG. **10** is a flowchart illustrating a method for forming a resistance memory device with a MSM back-to-back Schottky diode. The method starts as Step **1000**. Step **1002** forms a memory resistor bottom electrode (MRBE). Step **1004** forms a memory resistor (MR) material overlying the memory resistor bottom electrode. Step **1006** forms a MSM metal bottom electrode (MBE) overlying the memory resistor material, having a first work function. In one aspect, Step **1005** forms a memory resistor top electrode (MRTE) interposed between the memory resistor material and the MSM metal bottom electrode. Step **1008** forms a MSM semiconductor layer overlying the metal bottom electrode, having a second work function, less than the first work function. Step **1010** forms a MSM metal top electrode (MTE) overlying the semiconductor layer, having a third work function, greater than the second work function.

[**0057**] Forming the memory resistor material overlying the memory resistor bottom electrode in Step **1004** includes forming the memory resistor from a material such as PCMO, CMR film, transition metal oxides, Mott insulators, HTSC, or perovskite materials.

[**0058**] Details of fabricating the MSM diode are provided in the description of FIG. **9** and are not repeated here in the interest of brevity. Although the fabrication process specifically describes the formation of the MR device prior to (underlying) the MSM diode, in other aspects it would be possible to fabricate the MSM diode prior to (underlying) the MR device.

[**0059**] A MSM back-to-back Schottky diode, an MSM diode resistor memory device, and corresponding fabrication processes have been provided. Examples of process details have been presented to illustrate the invention. Likewise, a resistance memory device has been presented as an example of an application. However, the invention is not limited to merely these examples. Other variations and embodiments of the invention will occur to those skilled in the art.

We claim:

1. A method for forming a metal/semiconductor/metal (MSM) back-to-back Schottky diode, the method comprising:

providing a substrate;

forming a metal bottom electrode overlying the substrate, having a first work function;

forming a semiconductor layer overlying the metal bottom electrode, having a second work function, less than the first work function; and,

forming a metal top electrode overlying the semiconductor layer, having a third work function, greater than the second work function.

2. The method of claim 1 wherein forming the metal top electrode and metal bottom electrode includes forming the metal electrodes from the same material, having identical work functions.

3. The method of claim 1 wherein forming the metal top electrode and metal bottom electrode includes forming the metal electrodes from materials selected from the group consisting of Pt, Au, Ag, TiN, Ta, Ru, and TaN.

4. The method of claim 1 wherein forming the semiconductor layer includes forming the semiconductor layer from a material selected from the group consisting of amorphous silicon (a:Si), polycrystalline Si, InOx, and ZnO.

5. The method of claim 1 wherein forming the semiconductor layer includes depositing the semiconductor material using a process selected from the group consisting of atomic layer deposition (ALD), chemical vapor deposition (CVD), physical vapor deposition (PVD), spin-coating, direct current (DC) sputtering, radio frequency (RF) sputtering, and metalorganic chemical vapor deposition (MOCVD).

6. The method of claim 1 wherein forming the semiconductor layer includes depositing the semiconductor material to a thickness in the range of about 10 nanometers (nm) to 100 nm.

7. The method of claim 1 wherein forming the metal top and bottom electrodes includes forming each electrode with a thickness in the range of about 30 to 200 nm.

8. The method of claim 1 further comprising:

doping the semiconductor layer with a dopant selected from the group consisting of n-type and p-type dopants.

9. A method for forming a resistance memory device with a metal/semiconductor/metal (MSM) back-to-back Schottky diode, the method comprising: